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APPARATUS FOR ENERGIZING AN ELECTRICAL LOAD DEVICE

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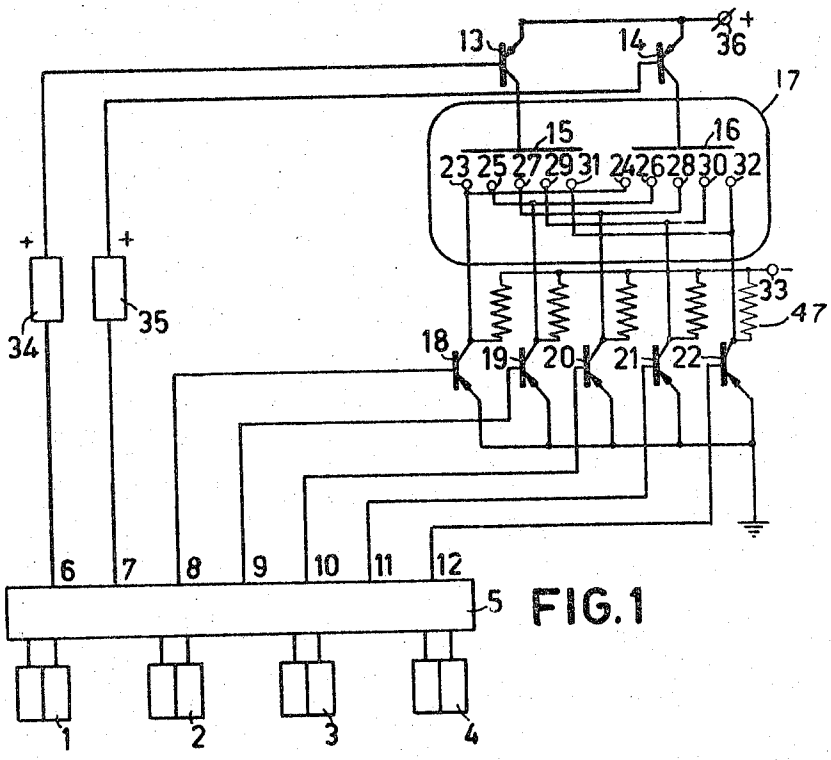

FIG. 1

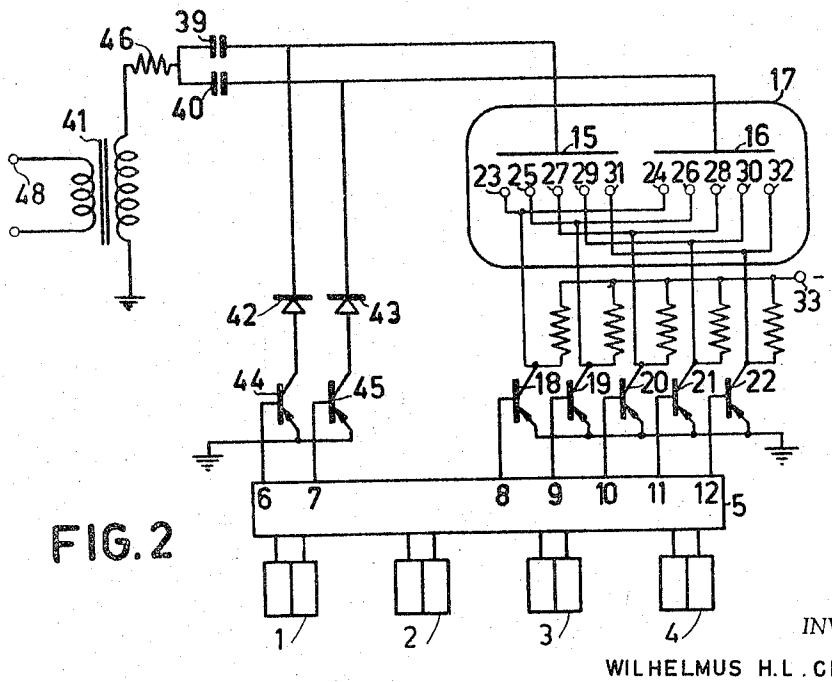

FIG. 2

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APPARATUS FOR ENERGIZING AN ELECTRICAL LOAD DEVICE

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This invention relates to apparatus for energizing an electrical load device, and more particularly to novel electronic switching circuitry for supplying energizing potentials to an indicating tube of the glow-discharge type, or the like.

There are numerous systems which require a device for reliably displaying in visual form coded information which is available in the form of discrete voltage levels. For example, in a digital computer, the results obtained at the end of a particular arithmetic operation are usually supplied in the form of binary voltage levels. Co-pending application, Serial No. 191,874, filed May 2, 1962, discloses a "biquinary" glow-discharge tube suitable for displaying binary coded or other forms of information in an easily readable decimal form of notation. This tube comprises a gas-filled envelope containing a plurality of cathode glow electrodes which are shaped in the form of numerals "0" to "9." The cathode electrodes are arranged in two groups of odd and even numbered electrodes. Each group has its own anode and the cathodes are connected together in electrode pairs, one electrode of each pair comprising an odd group cathode and the other electrode of the pair comprising an even group cathode. The two cathode electrodes of each pair are connected via a single electronic switching circuit to a source of energizing voltage. At any instant of time, dependent upon the value of the binary coded signal to be displayed, only a single electronic switching circuit will supply energizing potentials to a particular electrode pair. Each anode is also connected to individual switching circuits which supply energizing potentials thereto. Dependent upon whether the decoded signal is an odd or even value, one or the other of the anodes will be energized. Thus only one discharge path is formed between an anode and a cathode at any time and therefore only a single cathode will draw current and display the decoded digit. The voltage levels required to control both the anod and cathode switching circuits are usually derived from a single common decoding device. However, since the voltage level of the anode supply voltage to be switched is considerably higher than the cathode supply voltage to be switched, a voltage level changing circuit must be interposed between the decoding device and the anode switching circuits. This in turn makes the proper operation of the glow-discharge tube extremely sensitive to relatively small variations in the anode supply voltage, thereby necessitating the use of an extremely well regulated, and therefore expensive, source of anode supply voltage.

Accordingly, it is an object of this invention to provide an improved control circuit which eliminates the aforementioned disadvantages of the prior art arrangements.

It is also an object of this invention to provide a novel control circuit for operating an electrical load circuit which is relatively insensitives to supply voltage variations.

Another object of this invention is to provide a new and improved control circuit for reliably operating a glow discharge indicating tube despite variations in the supply voltage.

It is a further object of this invention to provide a novel control circuit for operating an electrical load which does not require the use of voltage level changing devices or circuits.

Another object of this invention is to provide a novel control circuit for operating a gas discharge tube with an A.C. supply voltage.

It is yet another object of this invention to provide a novel control circuit for energizing a biquinary gas discharge tube by means of transistor devices in the anode and cathode circuits of the tube, all of which operate at or near ground potentials.

These and other objects are accomplished in accordance with the invention by providing a novel control circuit for a biquinary indicating tube. The control circuit supplies an alternating current to the anodes of the tube and also produces a D.C. voltage. Switch means operating at relatively low voltage levels selectively apply the D.C. voltage to one or the other of the tube anodes in combination with the A.C. voltage. Other switch means are provided in the tube cathode circuits for selectively energizing the cathodes. The combined action of the anode and cathode switching circuits serve to establish current flow between a predetermined anode-cathode pair.

In a preferred embodiment of the invention, each anode of the biquinary tube is connected to a point of constant potential by means of a current path comprising the series combination of a capacitor and a source of alternating voltage. A second current path is provided in parallel with the first current path, and comprises the series combination of a rectifier device and a low level electronic-switching device, preferably a transistor. By means of the rectifier and electronic-switching device, an electrical charge is stored on the capacitor and combined with the A.C. supply voltage to provide energizing potentials sufficient to operate the tube to provide a visual read-out of the available information.

The invention will be more clearly understood by reference to the following description when read in connection with the accompanying drawing in which:

FIG. 1 is a schematic representation of one form of prior art arrangement;

FIG. 2 is a schematic representation of an arrangement embodying the invention.

Referring now to FIG. 1 of the drawing, there is shown one form of prior art control circuit for operating an indicating device **17** of the biquinary glow discharge tube type as disclosed in the above-mentioned co-pending U.S. application. In one form of the invention, the biquinary glow tube **17** is used to display the output of a binary counter composed of interconnected flip-flop trigger circuits **1** to **4**. The interconnections of trigger circuits **1** to **4** to provide a counting operation are well known and have been omitted from the drawing in the interests of simplicity and clarity. Trigger circuit **1** is assumed to be the lower order stage of the counter. At the end of a counting operation, a decoding device **5**, controlled by flip-flop triggers **1** to **4**, supplies an energizing voltage either to its output terminal **6** or to its output terminal **7**, depending upon whether the count in the counting circuit is an even or an odd number. Decoder **5** also determines the numerical count and supplies the proper energizing potentials at output terminals **8** to **12** so that only one cathode-pair of tube **17** will be energized at one time, dependent upon the numerical value, 0 to 9, stored in the counter. Transistor switching circuits **18** to **22** are controlled at their base electrodes by the decoder output voltages supplied from the terminals **8** to **12**, respectively. For any given count, four of the electronic switches **18** to **22** will be turned "on" and only one will be turned

"off." The collector electrodes of transistors 18 to 22 are connected to the interconnected cathodes 23–24, 25–26, through 31–32, respectively, of tube 17, and through identical resistors 47 to a source of negative supply voltage (not shown) applied to terminal 33. The emitter electrodes are connected directly to ground. Accordingly, only one pair of interconnected cathodes of tube 17 are supplied with the negative voltage at terminal 33 at any one time, i.e., the electrode-pair connected to the "off" transistor. The remaining four sets of electrode-pairs are brought to approximately ground potential due to the "on" condition of their associated transistors.

A positive D.C. supply voltage (not shown) is supplied to terminal 36. The odd and even anodes 15 and 16 of tube 17 receive a positive operating voltage from the D.C. voltage appearing at terminal 36 via switching transistors 13 and 14, respectively. The base electrodes of transistors 13 and 14 are supplied with switching voltages derived from terminals 6 and 7 of decoder 5 via voltage level changing devices 34 and 35. Transistor 13 will be turned "on" only when an odd valued number is stored in the counter, and transistor 14 will be turned "on" only for even valued numbers. Thus, only one discharge path is formed at any time between the anodes 15 or 16 and the cathodes 23 to 32. In operation, only one cathode of the energized cathode-pair will draw current and glow depending on which anode is energized. The even-number cathodes glow when anode 16 is energized, and the odd-number cathodes glow when anode 15 is energized.

The arrangement of FIG. 1 has the disadvantage that decoder 5, in general, can only furnish at its output terminals 6–12 a relatively small variation in D.C. voltage levels. The D.C. voltage levels supplied by decoder 5 at terminals 6–12 are somewhere in the vicinity of ground potential. However, because the emitter electrodes of transistor switching circuits 13 and 14 are connected to a relatively high positive D.C. supply voltage, voltage level changing devices 34 and 35 are necessary for bridging the relatively low direct-voltage levels at terminals 6 and 7 with the relatively high voltage level at terminal 36. Voltage level changing devices 34 and 35 are therefore interposed between terminals 6 and 7 and the control electrodes of electronic switches 13 and 14, respectively. D.C. batteries, zener diodes, gas-filled tubes, etc. could all be employed for devices 34 and 35. However, aside from the cost involved, this arrangement does not provide an entirely satisfactory solution, since a relatively small variation in the level of the positive D.C. supply voltage at terminal 36 will cause an erroneous adjustment of electronic switches 13 and 14. A small variation in the supply voltage at terminal 36 may change the operating levels of transistors 13 and 14 sufficiently so that one or both of the transistors 13 and 14 will always be held "on" or "off," depending on the extent of the change and the direction, i.e., whether terminal 36 becomes more or less positive with respect to its normal operating value.

The operating potentials supplied to glow discharge tube 17 may be in the range of from 100 volts to about 300 volts. However, because of the limitations in the maximum permissible D.C. voltages which can be safely applied across transistors 18 to 22, the negative supply voltage at terminal 33 cannot be made sufficiently negative so that terminal 36 could be supplied with approximately ground potential, rather than the high positive voltage required to properly operate tube 17.

The invention will now be described with reference to FIG. 2 which shows one embodiment of the invention. The preferred embodiment of the invention shown provides a solution to the above problem, which applies, in principle, for energizing any type of an electrical load. This embodiment is characterized in that the load is connected via a capacitor to an alternating-voltage supply source and, via the series combination of a rectifier and an electronic switch to a point of constant potential. In

FIG. 2, elements similar to those described with reference to FIG. 1 are designated by the same numerals. The counter circuits 1–4, decoder 5, cathode switching circuits 18–22, and the indicating tube 17 all operate similarly to the corresponding devices described with reference to the prior art arrangement of FIG. 1, and will therefore not be described in great detail with reference to FIG. 2.

Tube 17, of the type disclosed in the above-mentioned co-pending U.S. application, is connected with its multiple cathodes 23–32 via electronic switches 18 to 22 to a point of constant potential. Switches 18 to 22 may be, for example, PNP transistors of the type OC77. A negative voltage of, for example, 60 volts is supplied to the terminal 33. Anodes 15 and 16 of tube 17 are connected via capacitors 39 and 40, respectively, of approximately one microfarad, to an alternating-voltage source. The A.C. voltage source may conveniently comprise a transformer 41 connected to the A.C. supply voltage at terminals 48. Transformer 41 may be rated to supply a secondary voltage having a peak value of approximately 50 volts. The anodes 15 and 16 are also connected via rectifiers 42 and 43, respectively, and electronic switches 44 and 45, respectively, for example, PNP transistors of the type OC77, to a point of constant potential with respect to the control-voltages appearing at the terminals 6 and 7, respectively, of the decoding device 5.

The operation of the circuit is as follows: Let it be assumed that for a certain count stored in counter circuits 1–4, a negative voltage is produced at the terminals 6 and 9 to 12 of the decoding device 5, and at the terminals 7 and 8 a positive voltage is produced. Therefore, electronic switches 44 and 19 to 22 are conducting and electronic switches 45 and 18 are cut-off. Thus, the negative voltage at terminal 33 can only appear at the cathodes 23 and 24, connected to the collector electrode of cut-off transistor 18. The anode 15 is supplied not only with the alternating voltage across the secondary winding of the transformer 41, but also the direct voltage which is stored on the plates of the capacitor 39 and which is produced by rectification of the alternating voltage. Capacitor 39 is charged on alternate half cycles of the A.C. supply voltage by means of transistor 44 and diode 42. The voltage difference between the anode 15 and the cathode 23 is then sufficient to ignite the gas in the tube 17 in the area in the vicinity of said electrodes which causes cathode 23 to luminesce. This provides an indication of the state of decoding device 5 and the count stored in counter circuits 1–4.

Since the electronic switch 45 is not conducting under the assumed conditions, no charge current can flow via the rectifier 43 to the capacitor 40 (a small difference, if any, between the leakage currents of the semi-conductor elements 45 and 43 may, if necessary, be conducted away with the aid of a high resistance connected in parallel with the capacitor 40). Therefore, the only voltage appearing at anode 16 is that due to the A.C. supply voltage. The voltage difference existing between the anode 16 and the cathode 24 is then not adequate to produce a corresponding luminescence of the tube 17 in the area of the latter electrodes. If the voltage difference should exceed the ignition voltage of the tube 17, any spurious discharge between the electrodes 16 and 24 would extinguish rapidly, since the capacitor 40 would then be charged by the current flowing between said electrodes in a sense opposite to that necessary to sustain the glow, i.e., in a sense such that the voltage difference between the electrodes decreases.

A resistor 46, for example of 500 ohms, limits, if desired, the maximum switching-on current flowing through the electronic switches 44 and 45. If desired, this resistance may comprise the internal resistance of the secondary winding of the transformer 41. The voltage at the terminal 33 need not be a direct voltage. It may be an alternating voltage, for example, derived from the transformer 41.

It will be obvious that the arrangement of elements 39–45 may also be utilized for starting other loads which respond above a given minimum voltage. For example, tube 17 may be replaced by electromagnetic relays or the like, or by luminescent semiconductor devices luminescing under the action of sufficiently high voltages between the electrodes. Other obvious modifications will suggest themselves to those skilled in the art. Instead of using junction transistors having an emitter-collector amplification factor less than unity, use may also be made of controlled rectifiers having an amplification factor which is higher than one. It is therefore obvious that the novel control circuit of this invention, in its broad aspects, is not intended to be limited merely to the control of a biquinary glow discharge tube as in the embodiment disclosed herein, but is only limited in scope as defined in the appended claims.

What is claimed is:

1. A circuit arrangement for operating a gas discharge tube having first and second anodes and a plurality of odd and even cathodes, individual ones of said odd and even cathodes being electrically interconnected to form a plurality of electrode pairs, said circuit arrangement comprising a source of alternating voltage, means for supplying said alternating voltage to said anodes, means for producing a D.C. voltage, first switch means for selectively applying said D.C. voltage to said first or second anodes in series combination with said alternating voltage, a plurality of other switch means operating at a low voltage level, each of said electrode pairs being individually connected with a predetermined one of said other switch means, and means for selectively operating predetermined ones of said other switch means, said first switch means cooperating with said other switch means to establish current flow in said gas tube between a predetermined one of said anodes and a predetermined one of said cathodes.

2. Apparatus as described in claim 1 wherein said first switch means comprises first and second transistors each having a pair of input electrodes and an output electrode, means for connecting one of said input electrodes of each transistor to a point of constant potential and the other input electrode of each transistor to a source of switching voltage, and means for connecting the output electrode of said first transistor in circuit with one of said anodes and the output electrode of said second transistor in circuit with the other one of said anodes, said switching voltage source supplying operating voltages for operating said first and second transistors in mutually exclusive time intervals.

3. A circuit arrangement for energizing a gas discharge tube having first and second anodes and first and second cathodes individually associated with said first and second anodes, respectively, said circuit arrangement comprising first and second parallel connected branches connected between said first anode and a point of constant potential and third and fourth parallel connected branches connected between said second anode and said point of constant potential, each of said first and third branches comprising the series combination of an alternating current source and capacitance means, each of said second and fourth branches comprising the series combination of a rectifier device and electronic switch means, means for coupling said cathodes to a point of reference potential, and means for selectively actuating said electronic switch means so as to store an electrical charge on a predetermined one of said capacitance means derived from said current source, whereby the combined voltage produced by said current source and the charge on said capacitance means is sufficient to ignite said gas tube to cause a current flow between a predetermined anode-cathode pair.

4. A circuit arrangement for operating a gas discharge device of the type having first and second anodes individually associated with first and second cathodes, respectively, said circuit arrangement comprising a source of alternating current, first capacitance means serially connected with said current source and said first anode, second capacitance means serially connected with said current source and said second anode, means for connecting said first anode to a point of constant potential by means of a first current path comprising the series combination of a first rectifier device and first switch means, means for connecting said second anode to a point of constant potential by means of a second current path comprising the series combination of a second rectifier device and second switch means, means for selectively closing one of said switch means whereby the corresponding capacitance means stores an electrical charge derived from said current source, the combined voltage produced by said current source and the charge on said capacitance means being sufficient to ignite said tube to cause current flow between the anode connected to said charged capacitance means and its associated cathode.

5. A circuit arrangement for energizing a gas discharge tube of the type having first and second cathodes and first and second anodes operatively associated with said first and second cathodes, respectively, said tube having a given ignition voltage for establishing current flow between any given anode-cathode pair, said circuit arrangement comprising first switch means connected in the cathode circuits of said gas tube for selectively energizing said cathodes, a source of alternating voltage, means for supplying said alternating voltage to said anodes, means responsive to said alternating voltage source for producing a D.C. voltage, and second switch means for selectively interconnecting said alternating voltage source with said D.C. voltage producing means so as to selectively supply said D.C. voltage to said first or second anodes in combination with said alternating voltage to produce, in combination with said first switch means, a resultant voltage which exceeds said given ignition voltage across a given anode-cathode pair.

6. A circuit for energizing a load having a given threshold voltage comprising, a source of alternating current, a capacitor, means connecting said capacitor and said current source in series with a first input of said load, a second capacitor means connecting said second capacitor and said current source in series with a second input of said load, means connecting said first input to a point of reference potential by means of a first current path comprising, in series, a diode and first switch means, and means connecting said second input to a point of reference potential by means of a second current path comprising, in series, a second diode and second switch means.

7. A circuit as described in claim 6 wherein the maximum amplitude of said alternating current source is less than said threshold voltage and further comprising, means for coupling one terminal of said current source to said point of reference potential, and means for selectively operating said first and second switch means to establish a charge path between a given one of said capacitors and said current source which includes the associated switch means thereby to produce a resultant voltage at a given one of said load inputs which is the sum of the voltage of the alternating current source and the D.C. voltage on said given one of said capacitors, said resultant voltage being greater than said given threshold voltage.

8. A circuit as described in claim 7 wherein said load comprises a gaseous indicator tube having first and second anodes connected to said first and second inputs, respectively, and a plurality of cathodes connected in pairs, each of said anodes being operatively associated with one cathode of each pair of cathodes, said threshold voltage being the tube ignition voltage for establishing current flow between any given anode-cathode pair, and

separate switch means coupled to each pair of cathodes for simultaneously applying an operating voltage to both cathodes of a pair.

9. A circuit for energizing a load having a given threshold voltage comprising first and second parallel connected current paths connected to a first input of said load and third and fourth parallel connected current paths connected to a second input of said load, said first and third current paths each comprising, in series, an alternating current source and a capacitor, said second and fourth current paths each comprising, in series, a diode and electronic switch means, and means for selectively operating said switch means to establish a charge path for a given one of said capacitors which includes its associated switch means and alternating current source thereby to produce a resultant voltage at a given one of said load inputs which exceeds said given threshold voltage.

10. Apparatus as described in claim 9 wherein said second and fourth current path electronic switch means comprises first and second transistor devices, respectively, each having a pair of input electrodes and an output electrode, means for connecting one of said input electrodes of each transistor to a point of constant potential and the other input electrode of each transistor to a source of switching voltage, and means for connecting the output electrode of said first transistor in circuit with said first anode and the output electrode of said second transistor device in circuit with said second anode, said switching voltage source supplying operating voltages to said input electrodes for operating said first and second transistor devices in mutually exclusive time intervals.

11. A circuit as described in claim 10 wherein said load comprises a gas tube having first and second anodes connected to said first and second inputs, respectively, and a plurality of cathodes connected in pairs, each of said anodes being operatively associated with one cathode of each pair of cathodes, said threshold voltage being the tube ignition voltage for establishing current flow between any given anode-cathode pair, and a plurality of switch means individually coupled to given cathode pairs for selectively applying an operating voltage to a given cathode pair whereby a current path is established between a single anode-cathode pair.

12. A circuit arrangement for energizing a gas discharge tube of the type having first and second cathodes and first and second anodes operatively associated with said first and second cathodes, respectively, said tube having a given ignition voltage for establishing current flow between any given anode-cathode pair, said circuit arrangement comprising, a source of alternating voltage, means for supplying said alternating voltage to said anodes, means responsive to said alternating voltage source for producing a D.C. voltage, and switch means for selectively interconnecting said alternating voltage source with said D.C. voltage producing means so as to selectively supply said D.C. voltage to said first or second anodes in combination with said alternating voltage to produce a resultant voltage which exceeds said given ignition voltage across a given anode-cathode pair.

13. A circuit for energizing a load having a given threshold voltage for placing said load into operation comprising, a source of alternating voltage having a peak amplitude below said threshold voltage and coupled to one input terminal of said load, a capacitor connected in series with said alternating voltage source between said input terminal and a point of reference potential and capable of being charged to a given value of direct voltage, means for selectively adding said direct voltage to said alternating voltage to produce a resultant voltage across said load which is greater than said threshold voltage, said voltage adding means comprising said capacitor and unidirectional conducting switch means connected between said one terminal of the load and said point of reference potential, and means independent of said voltage source for selectively operating said switch means so as to establish a charge path between said capacitor and said voltage source thereby to charge said capacitor to said given value of direct voltage.

14. A circuit for energizing a load having a given threshold voltage comprising first and second parallel connected current paths connected between one terminal of said load and a point of reference potential, said first current path comprising, in series, a source of alternating voltage and a capacitor, said second current path comprising, in series, a diode and electronic switch means, means connecting the other terminal of said load to said point of reference potential so as to connect said load in parallel with said first and second current paths, and means for selectively operating said switch means to establish a charge path between said capacitor and said voltage source which charges said capacitor to a given value of direct voltage thereby to produce a resultant voltage across said load which exceeds said given threshold voltage.

15. A circuit for energizing a gas discharge tube having an anode and a cathode for establishing a current path therein, said tube having a given threshold ignition voltage, said circuit comprising, first and second parallel connected current paths connected between one terminal of said load and a point of reference potential, said first current path comprising, in series, a capacitor and a source of alternating voltage having a maximum amplitude less than said given threshold voltage, said second current path comprising, in series, a diode and electronic switch means, means connecting said tube current path in series with said one input terminal and said point of reference potential, and means for operating said switch means to establish a charge path between said capacitor and said voltage source which includes said switch means thereby to produce a resultant voltage across said load which exceeds said given threshold voltage.

References Cited by the Examiner

UNITED STATES PATENTS

2,682,002	6/1954	Gibson	307—110
2,773,221	12/1956	Shaw	320—1
2,906,906	9/1959	McCauley et al.	313—109.5
2,962,698	11/1960	Mathamel	340—168
2,999,968	9/1961	Weiss	320—1
3,119,950	1/1964	Somlyody	315—84.6

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